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such a green as we have never, either before or since, seen in the heavens. We saw patches or smears of something like verdigris-green in the sky; and they changed to equally extreme blood-reds, or to coarse brick-dust reds, and they in an instant passed to the color of tarnished copper or shining brass. Had we not known that these effects were due to the passage of the ash, we might well have been filled with dread instead of amazement; for no words can convey the faintest idea of the impressive appearance of these strange colors in the sky, seen one minute and gone the next, resembling nothing to which they can be properly compared, and surpassing in vivid intensity the wildest effects of the most gorgeous sunsets.

The ash commenced to pass overhead at about mid-day. It had travelled (including its détour to the west) eighty-five miles in a little more than six hours. At 1.30 it commenced to fall on the summit of Chimborazo, and, before we began to descend, it caused the snowy summit to look like a ploughed field. The ash was extraordinarily fine, as you will perceive by the sample I send you. It filled our eyes and nostrils, rendered eating and drinking impossible, and reduced us to breathing through handkerchiefs. It penetrated everywhere, got into the working-parts of instruments and into locked boxes. The barometer employed on the summit was coated with it, and so remains until this day. That which passed beyond us must have been finer still. It travelled far to our south, and also fell heavily upon ships on the Pacific. I find that the finer particles do not weigh the twenty-five thousandth part of a grain, and the finest atoms are lighter still. By the time we returned to our encampment, the grosser particles had fallen below our level, and were settling down into the valley of the Chimbo, the bottom of which was 7,000 feet beneath us, causing it to appear as if filled with thick smoke. The finer ones were still floating in the air, like a light fog, and so continued until night closed in.

In conclusion, I would say that the terms which I have employed to designate the colors which were seen are both inadequate and inexact. The most striking features of the colors which were displayed were their extraordinary strength, their extreme coarseness, and their dissimilarity from any tints or tones ever seen in the sky, even during sunrises and sunsets of exceptional brilliancy. They were unlike colors for which there are recognized terms. They commenced to be seen when the ash began to pass between the sun and ourselves, and were not seen previously. The changes from one hue to another, to which I have alluded, had obvious connection with the varying densities of the clouds of ash that passed; which, when they approached us, spread irregularly, and were sometimes thick and sometimes light. No colors were seen after the clouds of ash passed overhead and surrounded us on all sides.

I photographed my party on the summit of Chimborazo whilst the ash was commencing to fall, blackening the snow-furrows; and, although the negative is as bad as might be expected, it forms an interesting souvenir of a remarkable occasion.

EDWARD WHYMPER.

MODERN PHYSIOLOGICAL LABORATORIES: WHAT THEY ARE AND WHY THEY ARE.¹—II.

WE have seen that Haller laid the foundation of the knowledge that the body of one of the higher animals was essentially an aggregation of many organs, each having a sort of life of its own, and in health co-operating harmoniously with others for the common good. In the early part of this century, before scientific thought had freed itself from mediæval guidance, this doctrine sometimes took fantastic forms. For example: a school arose which taught that each organ represented some one of the lower animals. DuBois-Reymond relates that in 1838 he took down these notes at the lectures of the professor of anthropology:—

"Each organ of the human body answers to a definite animal, is an animal. For example, the freely movable, moist, and slippery tongue is a cuttlefish. The bone of the tongue is attached to no other bone in the skeleton; but the cuttlefish has only one bone, and consequently this bone is attached to no other. It follows that the tongue is a cuttlefish."

However, while Professor Steffens and his fellow-transcendentalists were theorizing about organs, others were at work studying their structure; and a great step forward was made in the first year of our century by the publication of Bichat's '*Anatomie générale*.' Bichat showed that the organs of the body were not the ultimate living units, but were made up of a number of different interwoven textures, or *tissues*, each having vital properties of its own. This discovery paved the way for Schwann and Schleiden, who laid the foundation of the cell-theory, and showed, that, in fundamental structure, animals and plants are alike, the tissues of each being essentially made up of aggregates of more or less modified microscopic living units called cells. Our own generation has seen the completion of this doctrine by the demonstration that the essential constituent of the cell is a peculiar form of matter named protoplasm, and that all the essential phenomena of life can be manifested by microscopic lumps of this material; that they can move, feed, assimilate, grow, and multiply; and still further, that, wherever we find any characteristic vital activity, we find some variety of protoplasm. Physiology thus became reduced, in its most general terms, to a study of the faculties of protoplasm; and morphology, to a study of the forms which units or aggregates of units of protoplasm, or their products, might assume. The isolation of botany, zoölogy, and physiology, which was threatened through the increased division of labor, brought about by increase of knowledge, necessitating a limitation of special study to some one field of biology, was averted; and the reason was given for that principle which we have always insisted upon here, — that beginners shall be taught the broad general laws of living matter before they are permitted to engage in the special study of one department of biology.

If I be asked, what have biological science in general, and physiology in particular, done for mankind

¹ Concluded from No. 50. Address by Dr. H. Newell Martin.

to justify the time and money spent on them during the past fifty years, I confess I think it a perfectly fair question; and fortunately it is one very easy to answer. Leaving aside the fruitful, practical applications of biological knowledge to agriculture and sanitation, I will confine myself to immediate applications of the biological sciences to the advance of the theory, and, as a consequence, of the art, of medicine.

So long as the life of a man was believed to be an external something apart from his body, residing in it for a while, diseases were naturally regarded as similar extrinsic essences or entities, which invade the body from without, and fought the 'vital force.' The business of the physician was to drive out the invader without expelling the vital spirits along with it,—an unfortunate result, which only too often happened. To the physicians of the sixteenth century a fever was some mysterious, extraneous thing, to be bled, or sweated, or starved out of the body, much as the medicine men of savages try to scare it off by beating tomtoms around the patient. Once life was recognized as the sum total of the properties of the organs composing the body, such a theory of disease became untenable, and the basis of modern pathology was laid. Disease was no longer a spiritual, indivisible essence, but the result of change in the structure of some one or more of the material constituents of the body, leading to abnormal activity. The object of the physician became, not to expel an imaginary, immaterial enemy, but to restore the altered constituent to its normal condition.

The next great debt which medicine owes to biology is the establishment of the cell-doctrine,—of the fact that the body of each one of us is made up of millions of little living units, each with its own properties, and each in health doing its own business in a certain way, under certain conditions, and no one cell more the seat of life than any other. The activities of certain cells may, indeed, be more fundamentally important to the maintenance of the general life of the whole aggregate than that of others; but these cells, which, by position or function, are more essential than the rest, were, in final analysis, no more alive than they. Before the acceptance of the cell-doctrine, pathologists were practically divided into two camps,—those who believed that all disease was primarily due to changes in the nervous system, and those who ascribed it to alteration of the blood. But with the publication of Virchow's 'Cellular pathology' all this was changed. Physicians recognized that the blood and nerves might at the outset be all right, and yet disease originate from abnormal growth or action of the cells of various organs. This new pathology, like the older, was for a time carried to excess. We now know that there may be general diseases primarily due to changes in the nervous system, which binds into a solidarity the organs of the body, or of the blood, which nourishes all; but we have also gained the knowledge that very many, if not the majority, of diseases have a local origin, due to local causes, which must be discovered if the disease is to be successfully combated. An engineer, if he find his machinery running imperfectly, may

endeavor to overcome this by building a bigger fire in his furnace, and loading the safety-valve. In other words, he may attribute the defect to general causes; and in so far he would resemble the old pathologists. But the skilled engineer would do something different. If he found his machinery going badly, he would not jump forthwith to the conclusion that it was the fault of the furnace, but would examine every bearing and pivot in his machinery, and, only when he found these all in good working-order, begin to think the defect lay in the furnace or boiler; and in that he would resemble the modern physician instructed in the cell-doctrine.

A third contribution of biology to medical science is the germ-theory as to the causation of a certain group of diseases. To it we owe already antiseptic surgery; and we are all now holding our breath in the fervent expectation that in the near future, by its light, we may be able to fight scarlet-fever, diphtheria, and phthisis, not in the bodies of those we love, but in the breeding-places, in dirt and darkness, of certain microscopic plants.

From one point of view the germ-theory may seem a return to the idea that diseases are external entities which attack the body; but note the difference between this form of the doctrine and the ancient. We are no longer dealing with immaterial, intangible hypothetic *somethings*; and the modern practitioner says, "Well, show me the bacteria, and then prove that they can cause the disease: until you can do that, do not bother me about them."

It is worth while, in passing, to note that these three great advances in medical thought were brought about by researches made without any reference to medicine. Haller's purely physiological research into the properties of muscles laid the foundation of a rational conception of disease. The researches of Schwann on the microscopic structure of plants, and since then of others on the structure of the lowest animals, led to the cellular pathology. Antiseptic surgery is based on researches carried out for the sole purpose of investigating the question as to spontaneous generation. My friend Dr. Billings has described "the languid scientific swell, who thinks it bad style to be practical, and who makes it a point to refrain from any investigations which lead to useful results, lest he might be confounded with mere practical men." Well, I am sorry for the swell; because, for the life of me, I cannot see how he can make any investigations at all. The members of his class must anyhow be so few in number that we need not much grieve over them. Personally I never have met with an investigator who would not be rejoiced to find any truth discovered by him put to practical use; and I feel sure that in this day and generation the danger is rather that disproportionate attention will be devoted to practical applications of discoveries already made, to the exclusion of the search for new truth. So far as physiology is concerned, it has done far more for practical medicine, since it began its own independent career, than when it was a mere branch of the medical curriculum. All the history of the physical sciences shows that each of them has con-

tributed to the happiness and welfare of mankind in proportion as it has been pursued by its own methods, for its own ends, by its own disciples. As regards physiology, this is strikingly illustrated by a comparison of the value to medicine of the graduation theses of Parisian and German medical students. As probably you all know, a candidate for the doctorate of medicine in those countries, as in many schools here, must present a graduation thesis on some subject connected with his studies. Every year a certain number select a physiological topic. The French student usually picks out some problem which appears to have a direct bearing on the diagnosis or treatment of disease, while the German very often takes up some physiological matter which on the surface has nothing to do with medicine. Now, any one who will carefully compare for a series of years the graduation theses in physiology, of German and French candidates, will discover that even the special practical art of medicine itself is to-day far more indebted to the purely scientific researches of the German students than to those of the French, undertaken with a specific practical end in view. Situated as we shall be here, in close relation to a medical school, and yet not a part of it, I believe we shall be under the best possible conditions for work. Not under too direct pressure of the influence of the professional staff and students, on the one hand, on the other we shall be kept informed and on the alert as to problems in medicine capable of solution by physiological methods.

I must find time to say a few words as to the connection of physiology with pathology and therapeutics. The business of the physiologist being to gain a thorough knowledge of the properties and functions of every tissue and organ of the body, he has always had for his own purposes to place these tissues under abnormal conditions. To know what a muscle or a gland is, he has to study it not merely in its normal condition, but when heated or cooled, supplied with oxygen or deprived of it, inflamed or starved, and see how it behaves under the influence of curari, atropine, and other drugs. From the very start of physiological laboratories, a good deal of the work done in them has necessarily been really experimental pathology and experimental therapeutics. I suppose to-day that at least half of the work published from physiological laboratories might be classed under one or other of these heads. And what has been the fruit? I can here refer only to one or two examples. It is not too much to say, that, though inflammation is the commonest and earliest recognized of pathological states, we really knew nothing about it until the experimental researches of Lister, Virchow, and Cohnheim; and that all we really know as to the nature of fever is built on the similar researches of Bernard, Haidenhain, Wood, and others. As to therapeutics, so far as giving doses of medicine is concerned, it, still in its very infancy, had its birth as an exact science in physiological laboratories. Every modern text-book on the subject gives an account of the physiological action of each drug. What the future may have in store for us by pursuit of these inquiries it is hard to limit.

The work of Bernard, — showing that in curari we had a drug that would pick out of the whole body, and act upon, one special set of tissues, the endings of the nerve-fibres in muscle, — and the results of subsequent exact experiments as to the precise action of many drugs upon individual organs or tissues, hold out before us a hope that perhaps at no very distant day the physician will know exactly, and in detail, what every drug he puts into his patient is going to do in him.

Pathology and therapeutics, while almost essential branches of physiological inquiry, have nevertheless their own special aims; and, now that the physiologists have proved that it is possible to study these subjects experimentally, special laboratories for their pursuit are being erected in Germany, France, and England. These laboratories are stocked with physiological instruments, and carry on their work by physiological methods. Those who guide them, and those who work in them, must be trained physiologists: if not, the whole business often degenerates into a mere slicing of tumors and putting up of pickled deformities: pathological anatomy is a very good and important thing in itself, but it is not *pathology*. Looking at the vast field of pathological and therapeutic research open to us, and bearing in mind the certainty of the rich harvest for mankind which will reward those who work on it, I regard as one of my chief duties here to prepare in sound physiological doctrine, and a knowledge of the methods of experiment, students who will afterwards enter laboratories of experimental pathology and pharmacology immediately connected with our medical school.

If the relations of the biological sciences to medicine be such as I have endeavored to point out, what place should they occupy in the medical curriculum? That men fitted for research, and with opportunity to pursue it, should be trained to that end, is all well and good; but how about the ninety per cent who want simply to become good practitioners of medicine? What relation is this laboratory to hold to such men, who may come to it, intending afterwards to enter a medical school? As a part of their general college-training, of that education of a gentleman which every physician should possess, it should give them specially a thorough training in the general laws which govern living matter, without troubling them with the minutiae of systematic zoölogy or botany; it should enable them to learn how to dissect, and make them well acquainted with the anatomy of, one of the higher animals; it should teach them how to use a microscope, and the technique of histology, and finally, by lectures, demonstration, and experiment, make known to them the broad facts of physiology, the means by which those facts have been ascertained, and the sort of basis on which they rest. The man so trained, while obtaining the mental culture which he would gain from the study of any other science, is specially equipped for the study of medicine. Trained in other parts of his general collegiate course to speak and write his own language correctly, having acquired a fair knowledge of mathematics and Latin, able to read at least French and German, having learned the

elements of physics and chemistry, and, in addition, having studied the structure and properties of the healthy body, he can, on entering the technical school, from the very first turn his attention to professional details. Knowing already the anatomy of a cat or dog, he knows a great part of human anatomy, and need do little but acquaint himself with the surgical and medical anatomy of certain regions. Knowing normal histology, he can at once turn his attention to the microscopy of diseased tissues. Well instructed in physiology, he can devote himself to its practical applications in the diagnosis and treatment of disease. The demand for an improvement in medical education, which has been so loudly heard in England and this country for some years, is (the more I think of it, the more I feel assured) to be met, not, as has been the case in England, by putting more general science into the medical-school curriculum, but by confining *that* more strictly to purely professional training, and by providing, as we have attempted to do here, non-technical college-courses for undergraduates, which, while giving them a liberal education, shall also have a distinct relation to their future work. Personally I regard it as the most important of my duties, to prepare students to enter medical schools in this city or elsewhere.

To advance our knowledge of the laws of life and health; to inquire into the phenomena and causes of disease; to train experimenters in pathology, therapeutics, and sanitary science; to fit men to undertake the study of the *art* of medicine, — these are the main objects of our laboratory. I do not know that they can be better summed up than in the words of Descartes, which I would like to see engraved over its portal: "If there is any means of getting a medical theory based on infallible demonstrations, that is what I am now inquiring."

THE CLOSING REPORT OF HAYDEN'S SURVEY.

Twelfth annual report of the U. S. geological and geographical survey of the territories: a report of progress of the exploration in Wyoming and Idaho for the year 1878. Washington, Government printing-office, 1883. 2 vols. 8°. With portfolio of maps and panoramas.

In two stout octavo volumes, with an accompanying portfolio of maps, Dr. Hayden presents the twelfth and last annual report of the Geological survey of the territories. While the late reorganization and consolidation of the surveys which have been occupied in the scientific exploration of the west is indubitably a very marked step in advance, it is not without a measure of regret that we realize that Dr. Hayden's familiar and always welcome annual report now reaches us for the last time. It is perhaps only those having some experience of similar work who can fully appreciate the energy and maintained scientific enthusiasm neces-

sary for the conduct of an organization such as that which under Dr. Hayden has built so broad a foundation for our geological knowledge of the western part of the continent.

The volumes now issued constitute the report for 1878, the concluding season of field-work. Great care has evidently been given to the editing and printing of the report; and the number and good quality of the illustrations and maps are noteworthy features. Of plates alone, in the two volumes, there are over two hundred and fifty; and most of them are excellent specimens of lithographic art.

The first volume is devoted chiefly to paleontology and zoölogy, while the second may be regarded as a memoir on the Yellowstone national park. Dr. C. A. White, in his report, under the title of 'Contributions to invertebrate paleontology, No. 2,' presents the second part of his descriptions and illustrations of cretaceous fossils. This is followed (as parts 4 to 8 of the contributions) by papers on tertiary, Laramie, Jurassic, triassic, and carboniferous fossils. The article on the Laramie, including, besides the descriptions and plates of a number of forms, a systematic enumeration of the invertebrate fossils of the group, assumes the character of a synopsis of its fauna invaluable to the student of this period of geological history. Mr. Orestes St. John's very comprehensive and systematic report on the Wind River district could be done justice to only in a separate note of some length.

Mr. S. H. Scudder's report on the tertiary lake-basin of Florissant is next in order. From this place a number of fossil plants and a few fishes and birds have been obtained: but it is specially remarkable for the wonderfully numerous remains of insects which it affords; "having yielded in a single summer more than double the number of specimens which the famous localities at Oeningen, in Bavaria, furnished Heer in thirty years." The fossils occur in fine-grained volcanic ash-beds, which, together with coarser materials of the same origin, constitute the deposits of the old lake-basin. The age of the beds is apparently about that of the oligocene, and the climatic conditions may have resembled those of the northern shores of the Gulf of Mexico at the present day. A complete description of the insects will be awaited with much interest. Mr. Packard's monograph of the phyllopod Crustacea of North America, having been already noticed in *Science*,¹ need only be mentioned. In the latter part of the first volume, Dr. R. W. Shufeldt treats of the osteology of the Cathartidae

¹ Vol. ii. p. 571.